sPHENIX SC-Magnet Review

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BNL

Topics

- **Magnetic stress calculations and fringe fields**
- **Magnet testing plans after the low power acceptance test**
- **SC-Magnet management team**
- **Open Issues**

Magnetic Stress Calculations

Questions to be answered:

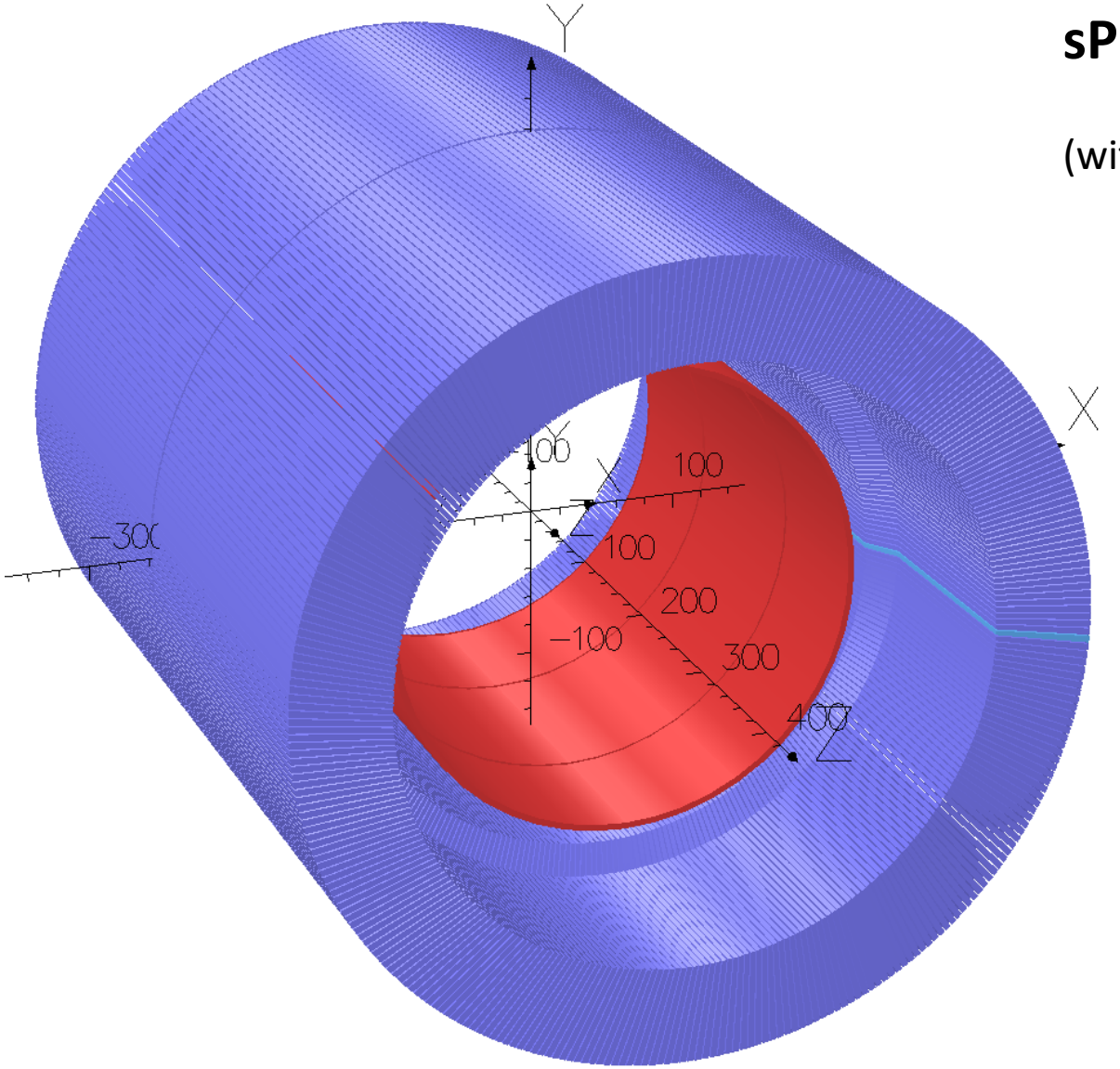
1. **Will the Outer HCal as designed work as a flux return?**
2. **What are the stresses on the Outer HCal with and without field plugs?**
3. **What is the fringe field outside the magnet with and without field plugs?**

4. **What are the stresses on the SC coils with and without the field plugs?**
5. **Can a full field test be performed without a flux return that does not put undue stress on the SC coils?**
6. **Can an end cap flux return be designed like that in the ePHENIX LOI without putting undue stresses on the SC coils?**

Wuzheng Meng of C-AD has calculated to answers to 1-3. He has used 3D-Opera and an Outer HCal design that incorporates the most important details of the planned sPHENIX HCal.

The answers to questions 4-6 will be calculable using the same approach.

The 3D Opera model includes the 320 calorimeter absorber plates surrounding the BaBar solenoid at the prescribed orientation and position.

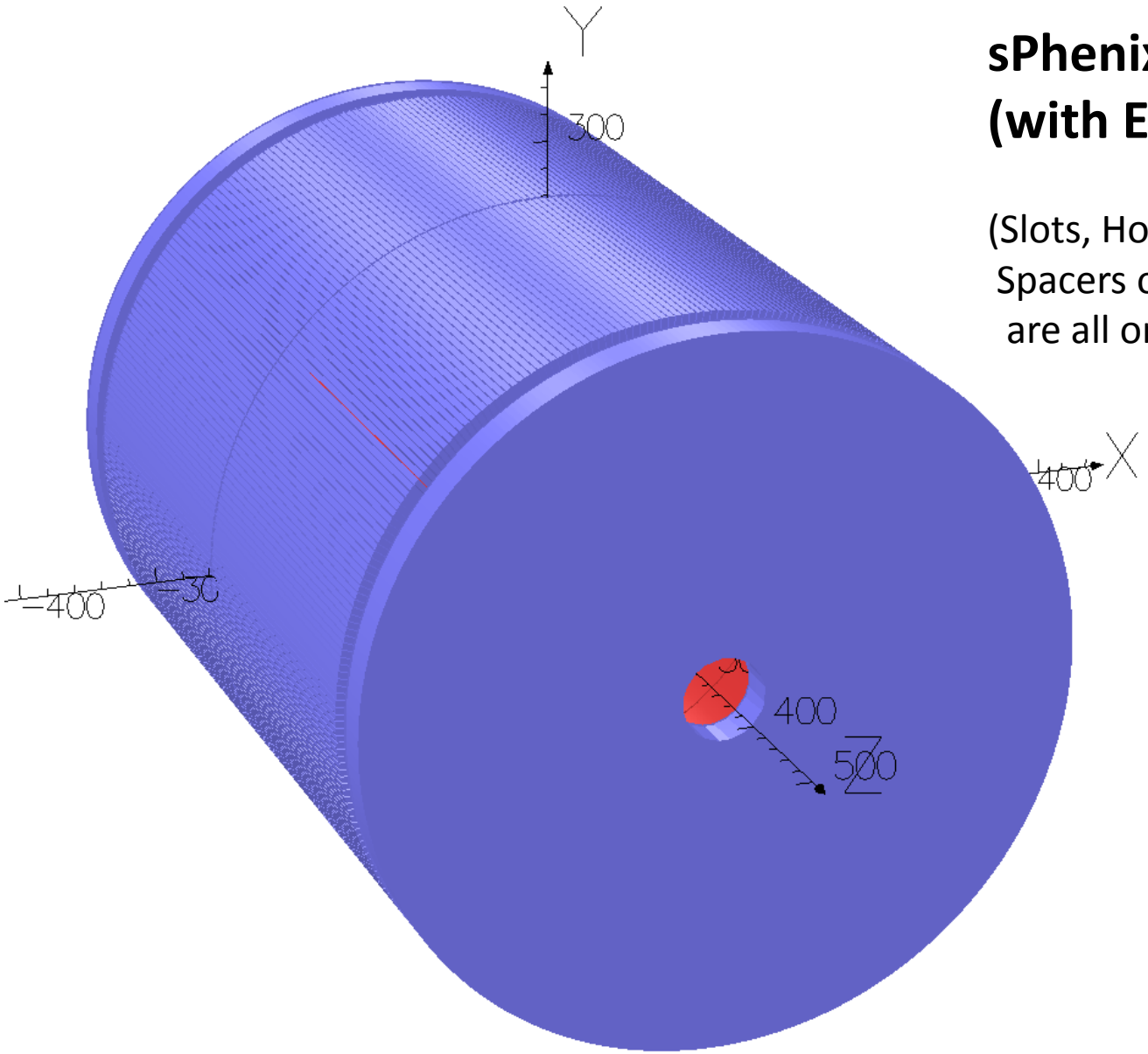


sPhenix Magnet

(without End-Caps)

Bo = 13965 G

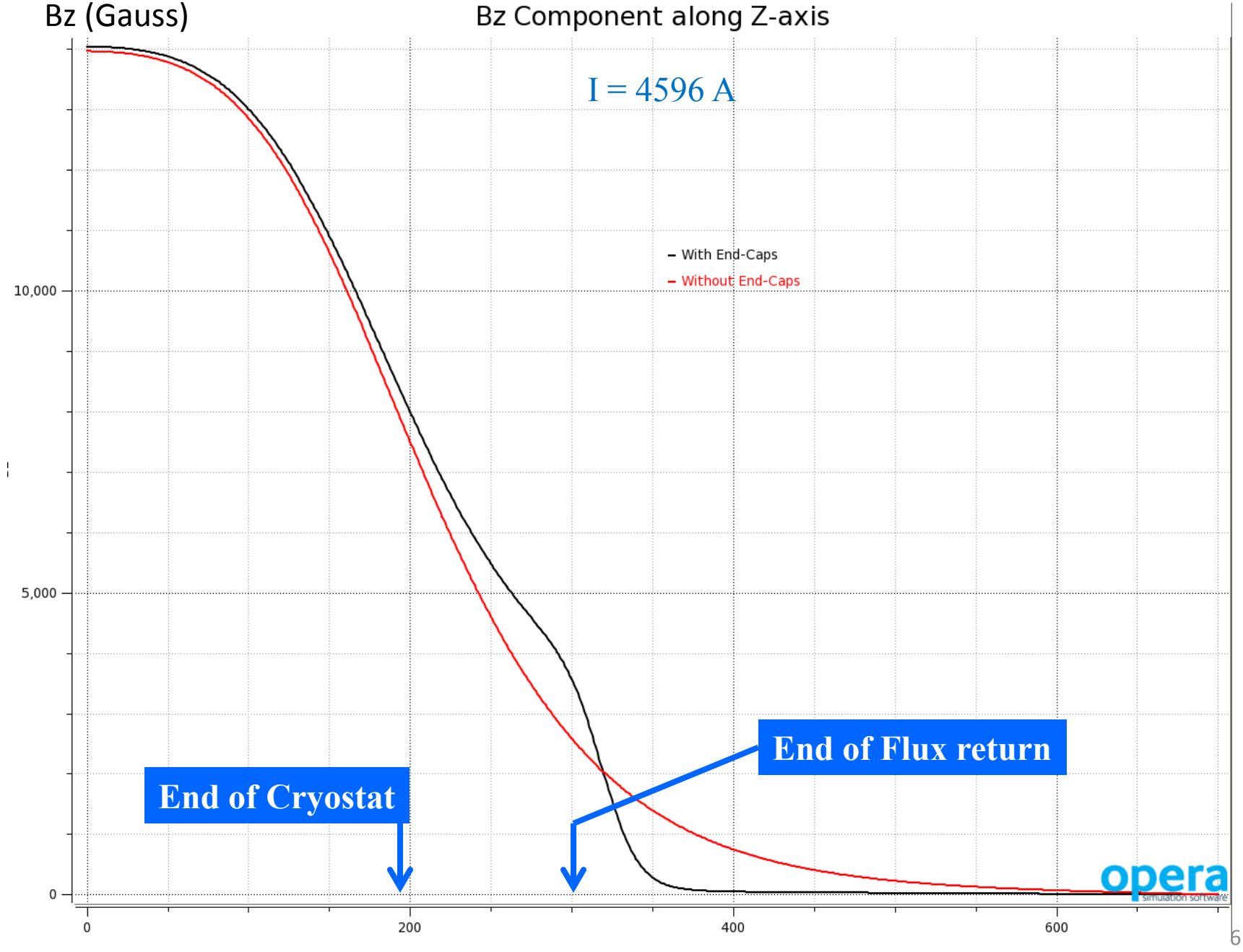
Each plate is magnet steel ~ 6m long x 82 cm in r x 2.5 cm thick tilted at 12^{o}



sPhenix Magnet (with End-caps)

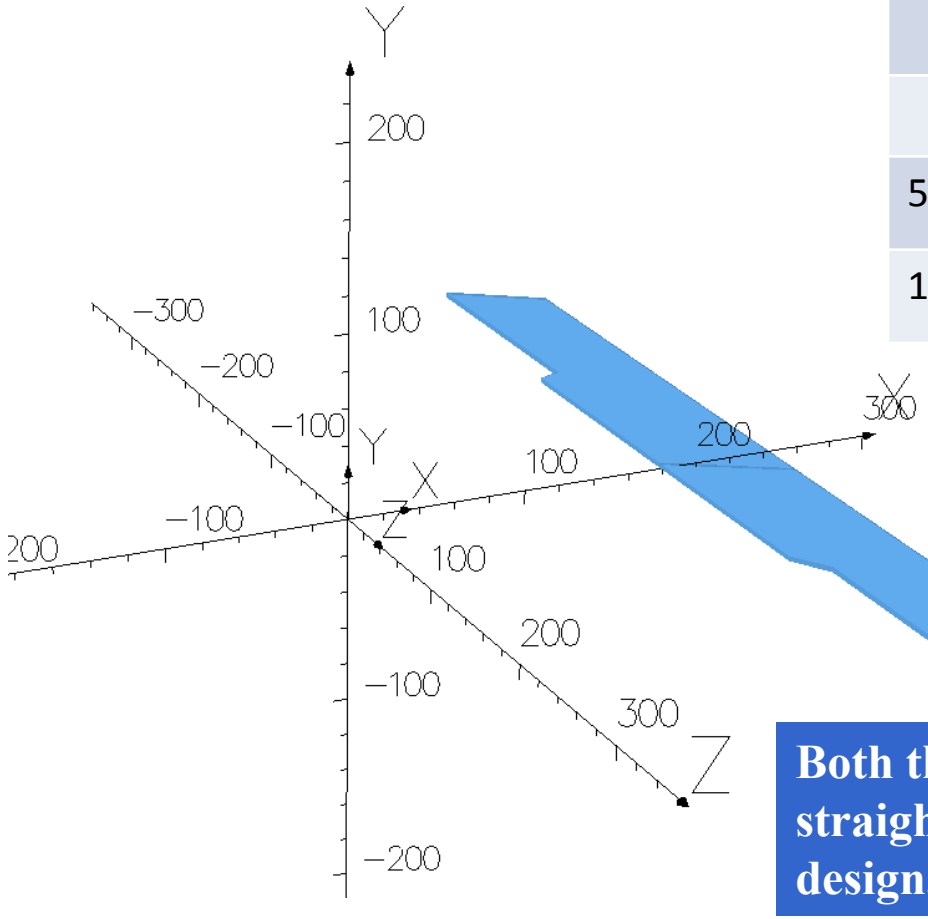
(Slots, Holes, and Spacers on caps are all omitted)

Bo = 14042 G


Bz (Gauss)
Bz Component along Z-axis
I = 4596 A
With End-Caps
Without End-Caps
10,000
5,000
0
0
200
400
600
End of Cryostat
End of Flux return
opera
simulation software

Forces and Torques on Each Steel Plate are Calculated by Integrating Maxwell Stress around its Surfaces (4596 A):

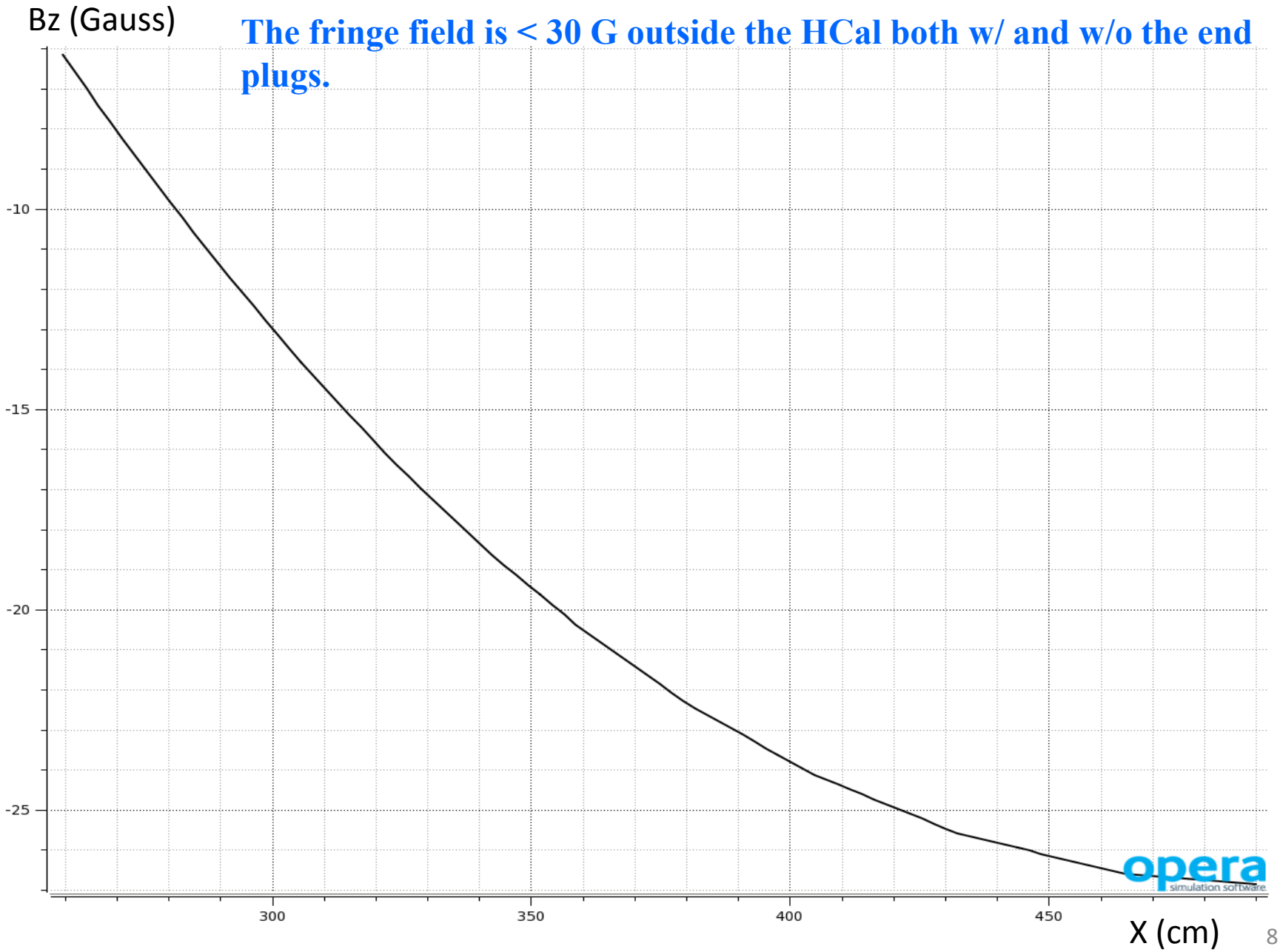
Without End-caps		Without End-caps	With End-caps
1607 lbs	Fx (N)	-7157.5	-6342.0
232 lbs	Fy (N)	-1032.2	-824.2
	Fz (N)	-2.6	-2.1
	Tx (N-cm)	-169.0	-139.8
58 ft-lbs	Ty (N-cm)	7886.0	6445.1
1544 ft-lbs	Tz (N-cm)	-209287.2	-166852.6



(1) The plate essentially sees a radial inward force;
(2) Tz indicates it has the tendency to rotate (with respect to the center of magnet).

Both the forces and torques on the HCal plates are straight-forward to deal with in the mechanical design. Neither are particularly challenging

Fringe Fields of sPHENIX Magnet outside yoke along X direction (Z=0)



Options for SC-Magnet High Field Tests

Can we find an effective way to test the BaBar magnet at BNL to full field, 4600A, without engendering any risks to the magnet? Based on recent experience, DOE may encourage us to test to full field as early as practical

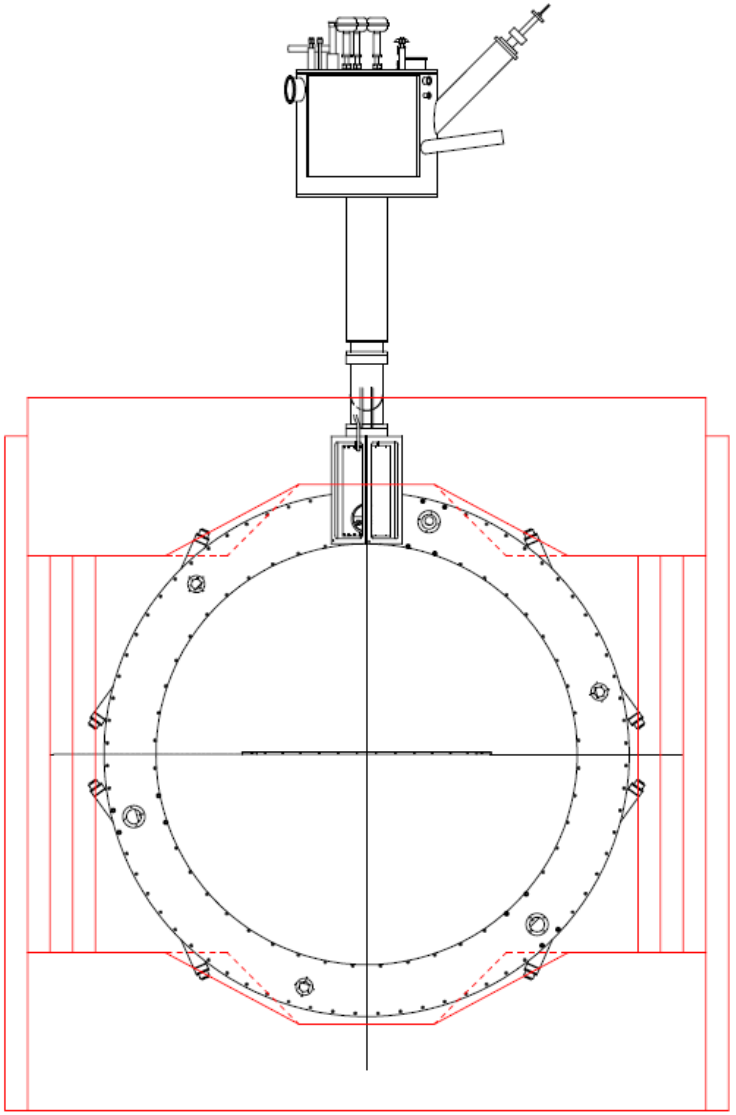
- **Test without a flux return in Bldg 912**
  - **Need to convince ourselves that this is safe for the magnet coils**
- **Test with a substitute flux return in Bldg 912**
  - **The steel may be available but the effort to assemble it may be a significant effort**
- **Test with the Outer HCal steel once it is available and assembled but before the calorimeter work is complete**
  - **Would require a delay in the calorimeter assembly schedule**
- **Test once the Outer HCal is fully assembled and the calorimeter tested.**
  - **Least intrusive option for the schedule, but this test comes late. Spring 2020.**

Summary of Testing Schedule

- **Babar magnet arrives at BNL** — **Jan 2015**
- **Low current magnet test prep Bldg 912** — **Jan-May 2015**
- **Low current test of Babar magnet** — **May – Jun 2015**
- **Earliest full field test in Bldg 912 assuming stand-in flux return can be found** — **~ mid 2016**
- **HCal steel available and assembled without scintillator plates** — **Sept 2019**
- **Earliest assembled HCal available for full field test with final flux return** — **Apr 2020**

Full Field Testing with a Stand-In Flux Return

- **Dave Phillips is investigating whether a full field test could be carried out in 2016 in Building 912 using spare steel from the EVA and MPS experiments.**
- **The benefit of learning early whether we have a fully functional SC-magnet may be worth the additional work.**
- **The investigation is still in its initial stages.**



SC-Magnet Management Team

Management through the low power test:

Mike Anerella – Manager of the LP test

Dave Phillips – Facilities, installation, engineering support

Roberto Than – Cryogenics

Bob Lambiase –PS and Controls

Proposal for Management through the completion of sPHENIX:

Dave Phillips + CAD Physicist – **Level 2 Manager**

Roberto Than – Cryogenics

Bob Lambiase – PS and Controls

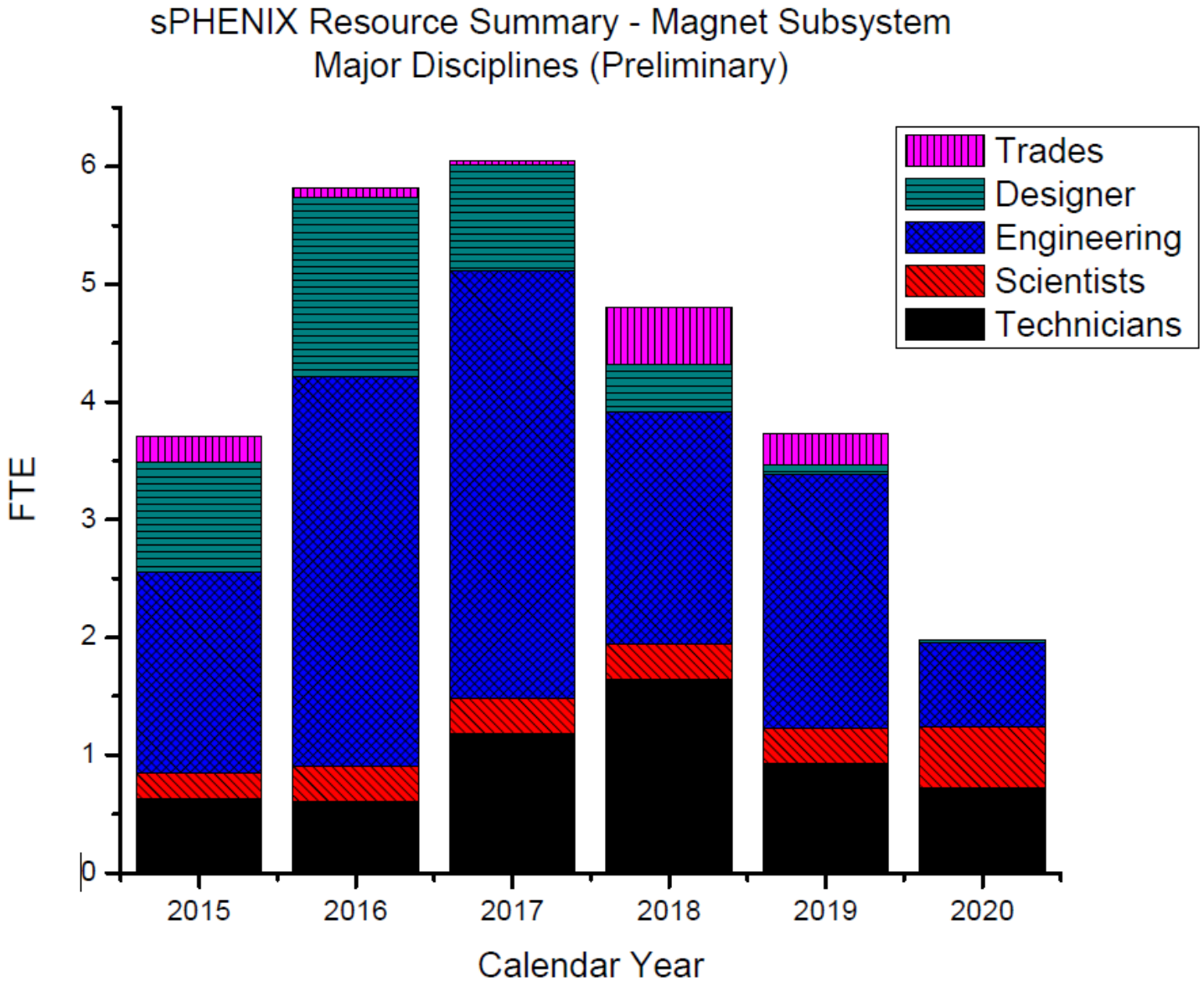
Achim Franz – Magnet Mapping

} **Level 3 managers**

Dave Phillips – Facilities, installation and engineering support

Additional support will be needed from C-AD cryo and PS groups, ES&F esp. Wuzheng Meng and consultation w/ SMD

SC-Magnet Labor Distribution



Some Issues

- **Set the L2 manage of the SC-Magnet as soon as possible.**
- **Complete the magnetic force studies including:**
  - **Forces on the SC coils in the sPHENIX configuration**
  - **Forces associated with a flux return built into a forward arm as might be used in sPHENIX or an EIC experiment.**
  - **Forces under a quench condition.**
- **Can we do a full field magnet test relatively early in sPHENIX construction?**
- **Can we live with the fringe field in the 25 Gauss range near the local racks?**
- **There is also a wide variety of installation, alignment, cryo , controls and quench protection issues that is to be expected for a project at this stage.**

Summary

- **The BaBar magnet+Outer HCal + end plugs have been modeled in 3D OPERA at full field**
  - **The Outer HCal works as a flux return**
  - **The forces on the HCal plates are tractable. The HCal mechanical design will take the magnetic forces and torques into account.**
  - **The fringe field is similar both with and without the end plugs. It is < 30 G except along the beam axis. We'd like it a little lower from the perspective of local rack electronics but we probably can deal with it.**
  - **We next need to calculate the forces on the SC coils under various assumptions.**
- **We're investigating the options for doing a full field test of the BaBar magnet at BNL**
  - **Doing a full field test w/o a flux return seems implausible but we haven't completely ruled it out.**
  - **Other full field test options include an early test with a substitute flux return, a test using the HCal steel prior to calorimeter assembly and a test after the HCal is completely assembled.**
  - **Each option has a down side**

Summary - continued

- **sPHENIX has received outstanding support from SMD and C-AD for the planning of the BaBar magnet move to BNL and the preparation for its arrival.**

- **Significant effort is needed between now and the completion of sPHENIX for the testing, modification, integration and installation of the SC-magnet.**

- **The project plan to successfully test and install the SC-magnet involves the use of significant resources from both C-AD and SMD.**